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CHEMICAL STUDIES ON MENTHA*

IV. On the Fragrance and Odor of Japanese Peppermint**

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長沢　徹：薄荷属植物の化学的研究

第４報　日本ハッカの香気と臭気について

I　INTRODUCTION

The fragrance of peppermint is known as a special odor in general. But their knowledges for mint's odor are very poor. First of all, we wish to think the flavor of the Japanese peppermint. When we take the peppermint as an aromatic plant, we can smell the refreshing odor evaporated from a living plant. And, then, we think what kind of scent this is. The odors evaporated from plants are very few, but we can feel very volatile odor surely.

The odor of essential oils obtained by steam distillation, however, is felt stronger than that of direct living plant, and almost accompany with unpleasant odor. It means probable that the difference of concentration and ratios of the volatile substances and the second generation of smelling matter from plants by influence of physical and chemical operations.

The *menthol* crystals and peppermint oils of Japanese peppermint manufacture have a special fragrance of the Japanese natural peppermint goods. The Japanese peppermint manufacturers, world dealers and consumers of the peppermint were intimated with its fragrance and taste since long time. However, comparing with fine fragrance and cool taste of Mitcham peppermint (*M. piperita*) the Japanese one (*M. arvensis*) is ranked lower.

Recently, the synthetic *menthol* came to use in Japan, while the man-made *methols* are practical use in Europe and America since early time. This fact break out the hard idea of the scent of natural *menthol*. The strong odor of Japanese natural *menthol* has hitherto considered to be good and normal state. That wrong idea of mint odor is very strong, so it was very hard to destroy the long customed thoughts of consumers. Accom-

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panied, however, with the advance of man-made goods in the market, it is delightful that the recognition of the flavor of peppermint was changed.

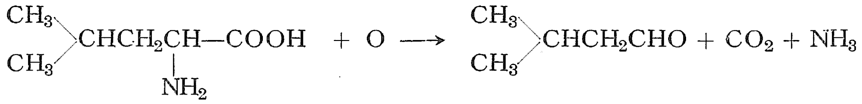
The Japanese peppermint has a good character of the highest content of *menthol*, but the Japanese monopolistic production of peppermint became a faint dream of the past. Nowadays, natural *menthols* are coexistent with synthetic ones in Japan. If the flavor and taste of natural *menthol* is continued as an old idea, it is regrettable to worse fortune of the future of Japanese natural *menthols.*

Judging from the studies of the writer1) 2) the cool taste and cheerful fragrance of the Japanese peppermint oils depends mainly in *l-menthol* and *menthyl acetate*, and *menthone* acts as a blender of them to make mild scent. While the scent of fresh peppermint grass are agreable, bad odors of aldehydes, ketones,3) amines4) and sulfides appeared on steam distillation of the grasses. It is notable that these components of bad odors are almost water-soluble and exist in lower-boiling portion.

Terpene hydrocarbons are almost worth nothing. *Pulegone* of Dog-mint5) has a strong odor, which is distinguishable easily by any one. Again, disagreable odors exist mainly in higher boiling portion of mint oils and they result mainly from higher esters (e. g. *β, γ-hexenyl phenylacetate*).6) Is it a fatality of Japanese mentha having impressive hard volatile odors ? The writer wishes to report on the odor and deodorization of the Japanese peppermint oils.

The original oils of Japanese peppermint contain about 85 per cent of *l-menthol,* and 2～4 per cent of menthyl ester. They have an important part as a native perfume goods in Japan. But they are inefrior to foreign goods on smell and taste. The inferiority of Japanese mint as described above, exists in amines4) and carbonyl compounds.3)

The creation of essential oils in plant is assumed as the product from the synthesis of proteins by carbohydrates and *nitrogen* transformed by root, then the decomposition of protein to amino acids. The essential oils are formed by the secod decomposition of amino acids as : —



$$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CHCH_2\underset{\begin{matrix}|\\NH_2\end{matrix}}{CH}-COOH + O \longrightarrow \begin{matrix}CH_3\\CH_3\end{matrix}\!\!>CHCH_2CHO + CO_2 + NH_3$$

Leucine Isovaleric aldehyde

This amino acid transformed easily to aldehyde7) by oxidation in presence of sugars. The amines in peppermint oils are confirmed as *isoamylamine, diisoamylamine, triisoamylamine,*8) *ammonia* and *trimethylamine.*9)

It is probable that we suppose the presence both amines and aldehydes in the essential oils. The writer, therefore, schemed to eliminate amines of bad odor by treatment with inorganic acids, and almost succeeded to his purpose.

II INVESTIGATION ON THE FLAVORS OF JAPANESE MINT10)

In studying Japanese mentha the writer has taken mind on both sides of *menthol* crystals and fragrance of original (Tori-oroshi) oil. We must not forget the importance of fragrance of mint plant and *menthol* crystals of synthetic field.

The bitter taste and offensive odors are difficult to deprive by steam distillation. But using high vacuum, we can almost eliminate bad odor and bitter taste in the first running and after running fractions, respectively. To think the problems of flavors of mint oil, we take *menthone* content as in the Table 1 11), that while the Mitcham peppermint oil contains under 15 % of it, that of both in Japan and Soviet Russia are rich in *menthone*. The reason of it is probably said that the crops of mint plant in Japan and Soviet Russia are in bud stage. Rutowski and Trawin (1929)12) reported the increase of *menthol* during growth, while the *menthone* decreased on the contrary. The writer has observed the same result in studying Japanese peppermint13). The fact of high content of *menthone* (over 15%) gave uninteresting influence to the fine flavor of the peppermint oils.

Table 1. Properties of Peppermint Oils of the World

	Japan Dementholized oil	America	Italy	Russia	France	Germany	England
d	0.901	0.905	0.910	0.903	0.905	0.904	0.905
α	−28°40′	−26°40′	−18°	−26°45′	−20°40′	−27°20′	−23°5′
Solubility (70%Ethanol)	1 : 3	1 : 4	1 : 3.4	1 : 3	1 : 2.8	1 : 2.8	1 : 3
Ester (%)	10.5	7.6	5.2	5.4	4.95	7.4	4.1
Ester Menthol (%)	8.3	6.0	4.1	4.6	3.95	5.8	3.7
Total Menthol (%)	52.0	52.9	49.2	48.3	49.1	59.0	65.1
Menthone (%)	25.0	9.0	15.0	19.0	12.0	14.6	9.8
Resinous matter (%)	0.9	1.2	0.65	2.3	0.8	0.8	0.85

(From T. Nagasawa : "Peppermint and Pyrethrum" (**1942**))

The writer would take some compounds as *pulegone, piperitone, β,γ-hexenol, β,γ-hexenyl phenylacetate, α,β-hexenic acid* for the reason of bitter taste and disagreable odor of the Japanese mint oils. The aroma of peppermint oils, sometimes, refer to the field distillation of mint plants. Any weeds in the field may be mixed carelessly in mint grass, and rope of straw binding mint grass brings the cause on lowering the qualities of the oil. The writer has advocated long time, the importance of fragrance and flavor rather than much yield of *menthol* crystals of mint plant. The *menthol* crystals needed to possess exciting fragrance and cool taste.

III THE REAL CHARACTER OF JAPANESE PEPPERMINT14)

The air dried peppermint grasses are called "Ha-Go" (lovely name of leaves of mint plant) by the cultivaters and manufacturers. The expert dealers esteem acculately the oil yield by years' experience and perception amazing at the appearance and scent of the mint grass. They discriminate the grass to be good or bad, principally by the sharp scenting. By scenting the mint grasses they separated Aka-Kuki (Red-stem), Aô-Kuki

(Green-stem) or Inu-Hakka (Dog-mint). Red-stem has a strong odor of *menthol*, Green-stem has relatively weak odor, but Dog-mint presents strong odor of *pulegone* which is disliked by the farmer and manufacturer.

The principal cause of Dog-mint which disliked by manufacturer and cultivater, exist in very small content of *menthol* rather than its odor. The odor of Dog-mint comes from *pulegone*. There is a proverb in peppermint district — "Dogs eat brain" — Dog-mint oil dissolves large quantity of *menthol* crystals at ordinary temperature.

In the suburbs of Osaka, there grew odorous grass called "Cows not eat", which was found to be "Oranda-Hakka" (*Mentha viridis*, L., var, *crispa*, Benth.) by the writer[15] and confirmed *l-carvone* as the principal constituent (above 50%) of the essential oil.

IV CHEMISTRY OF JAPANESE MENTHA

Piperitone has a disagreable odor and deep bitter taste, and *pulegone* has a queer odor in the Japanese peppermint (*M. arvensis*) oils. A strange bad odor accompanied in the high boiling fraction, rather in the residual portion of distillation of mint oils. The substance, having very offensive odor, was found by German chemist, H. Walbaum (1917),[6] to be an ester of *β,γ-hexenol* and *phenylacetic acid*. This *β,γ-hexenol* has an odor of green leaf, therefore it was called "Blätter Alkohol" or "Leaf alcohol", and "Aôba-alcohol" in Japan.[16]

The chemical constituents of Japanese mentha are shown in the Tables 2 and 3.

Table 2. Principal Constituents of the Essential Oils of Mentha

Constituents	(*M. arvensis*) Dementholized oil (%)	(*M. arvensis*) Dog-mint (%)	(*M. viridis*) Japanese-spearmint (%)
l-Limonene	10	10	30
l-Menthone	25	30	—
l-Menthol	40	30	—
Menthylacetate	10	5	—
Piperitone	5	5	—
d-Pulegone	—	20～30	—
l-Carvone	—	—	50～60

Other special constituents in *M. arvensis* : -
Ethyl-n-amylcarbinol,
β,γ-Hexenol, Phenylacetic acid

Table 3. Chemical Constituents of Japanese Mint Oil (*M. arvensis*)

Hydrocarbons :	*Alcohols* :	*Aldehydes*:
1. α-Pinene	7. *l*-Menthol	13. Acetaldehyde
2. Camphene	8. *d*-Neomenthol	14. Isovaleric aldehyde
3. *l*-Limonene	9. *d*-Ethylamylcarbinol	15. Furfural
4. *p*-Menthene	10. β, γ-Hexenol	
5. Myrcene *	11. Borneol	
6. Sesquiterpene	12. Sesquiterpene alcohol	

Ketones :
16. *l*–Menthone
17. *r*–Isomenthone
18, *d*–Isomenthone
19. Piperitone
20. *d*–Pulegone
21. Acetone
22. Methylethyl ketone
23. Methylamyl ketone
24. 1–Methyl–3–cyclohexanone
25. Methylheptenone
26. 2–Isopropylcyclopentanone **

Acids:
27. Formic acid
28. Acetic ”
29. Isovaleric ”
30. Caproic ”
31. Oenantic ”
32. Pelargonic ”
33. Phenylacetic ”
34. *α*, *β*–Hexenic ”

Phenols :
35. Thymol
36. Eugenol

Oxides :
37. Menthofuran ***
38. Piperitone oxide ****

Amines:
39. Ammonia
40. Monomethylamine
41. Trimethylamine

Sulfides:
42. Hydrogensulfide
43. Dimethyl sulfide

* Found by M. Kobayashi and K. Katsuhara (1961),
** Found by T. Onogaki (1961),
*** Found by H. Hadano (1956),
**** Found by M. Kobayashi, E. Yoshigi and K. Katsuhara (1960)

The odor and taste of Japanese mint oil (*M. arvensis*) is severely pungent and bitter. The pungent taste is by *menthol*, and bitter taste by *piperitone*. Their contents are shown in the Table 4.

Table 4. Composition of Mint Oil in regard to Flavor and Taste

Region	Menthol		Menthone (%)	Piperitone (%)
	Free (%)	Combined (%)		
Hokkaido	68.0	5.7	12.9	2.0∼4
Okayama	78.8	4.2	9.7	1.7
Okinawa	80.9	5.9	4.4	2.0
Taiwan	58.6	13.2	—	9.5
Korea	74.0	4.4	9.3	2.4
Manshu	29.0	49.0	—	few
China	79.9	4.5	—	2.2
Brazil	46∼70	19∼45	—	—

The Japanese mint (*M. arvensis*) oils, as shown in the Table 4, contain *piperitone* with no exceptions. The oil of Manshu and Brazil contain relatively few *menthol* but large quantities of *menthyl acetate* (19∼49%). The *menthyl acetate* has a good fragrance. The writer has studied some mint plants in Japan, and named four groups by principal component of their essential oils, as : — (1) *Menthol*-mint, (2) *Menthone*-mint, (3) *Pulegone*-

mint, (4) *Carvone*-mint.

These species have special fragrance and taste.

We know hitherto why the Mitcham peppermint stands at the highest rank of all peppermints in the world. Doctor Schmidt (1947)17) of Schimmel & Co. investigated the odorous substances of peppermint produced in America, Soviet Russia, Italy and Bulgaria. He found many new compounds in the oils, and found *jasmone*, which existed in jasmin flowers, among other ones. And he announced this one is not existent in Japanese peppermint oils. Again the existence of *menthofuran*18) in Mitcham mint gave us an interesting problem regarding mint odors. For the reference, the properties of pepper mint oils of each country are shown in the Table 5.

Table 5. Properties of Peppermint Oils of Each Country

Species	District	Menthol Free (%)	Menthol Combined (%)	Menthone (%)	Pulegone (%)
Japanese mint (*M. arvensis*)	Okayama-pref.	70∼82	3∼ 6	7∼14	—
	(Dementhol.)	41∼43	6∼ 3	23∼30	—
European mint (*M. piperita*)	America	40∼50	5∼ 9	9∼16	—
	England	40∼45	3∼21	9∼12	—
	France	35∼40	4∼21	—	—
	Germany	40∼60	3∼21	12∼23	—
Pennyroyal (*M. pulegium*)	France	2∼ 3	3∼ 5	—	80—88
	America	—	—	50	30

		Carvone (%)	Linalool (%)
Spearmint (*M. viridis*)	England	30∼48	—
	America	36∼48	—
	Russia	6∼10	50∼60
	Japan	50∼60	—

V FRAGRANCE OF NATURAL L-MENTHOL

Crude *l-menthol* crystals were refined by recrystallization with ligroin, and the fragrance and taste of each refined *menthol* was examined.

Table 6. Taste of Menthols

Sample Menthol	Weight (g)	Crop of crystals (g)	m. p. (°C)	Fragrance, Taste
Aka-Kuki	5	3.8	42∼43	Strong aroma, and Pungent bitter
San-Bi	5	3.9	42∼43	Cold, sweet
* Co-menthol from Aka-Kuki	5	2.0	42∼43	Mild, bitter

N. B. * Co-menthol : Menthol from borate.

〔Experimental〕 Samples : Refined *menthol* crystals of (1) Aka-Kuki (red-stem), (2) San-Bi, (3) Co-menthol* of Aka-Kuki.

Take 5g. of each *menthol* crystal, separately, in a small beaker and poured 7cc. of ligroin. The solution was filtered and the filtrate was concentrated adequately. The deposited crystals were obtained as in the Table 6.

The keeping of odor :

〔Experimental〕 The odors of several mint oils we obtained were compared by their keeping of volatility. Any definite quantity of each sample oil was dropped by the capillary on the testing paper (made of filter paper) and their odor was smelled at proper intervals of time. The results are shown in the Table 7 and 8. *Menthols* are used as 10 per cent *ethanol* solution.

Table 7. The Keeping of Odor of Mint Oils (1)

	Mint oil	1 hr	2 hr	5 hr	20 hr	26 hr
M. arvensis	San-Bi	+ + + + + (bad)	+ + +	+ +	+	± (borneol)
	Fragrant mint	+ + + + + (good)	+ + +	+ + (menthol)	+	−
	Brazil	+ + + + + (good)	+ + +	+ + (menthol)	+	±
	Dog-mint	+ + + + (pulegone)	+ + +	+	+	±
	Horse-mint	+ + + + (menthone)	+ + +	+	±	−
	Imaichi (Hybrid)	+ + + + (bad)	+ + +	+	±	−
M. viridis	Chirimen (red)	+ + + + +	+ + + +	+ (butter)	+ (butter)	±
	Chirimen (white)	+ + + + +	+ + + +	+ (butter)	+ (butter)	±
	Soviet	+ + + + (good)	+ + +	+ +	+ (linalool)	±
	M. Pulegium	+ + + +	+ + +	+	±	−

N. B. + indicates strength of odor
− indicates no more odor

From these experiments the writer found the facts that fine smell distinguishes in short time, but disagreable odor continued long time. This fact indicates us the bad odor almost has a long life.

Table 8. The Keeping of Odor (2)

Unit oil	1 hr	2 hr	5 hr	20 hr	26 hr
First running	+++ (bad)	+	±	−	−
Turbid oil	+++++ (bad)	++++	++++	+++	++
Liquid oil from borate	+++++ (bad)	++++	++ (menthol)	+	±
Menthone	+++	+	−	−	−
Menthyl acetate	+++ (good)	++	+	±	−
Thymo-menthol	+++	++	+	± (borneol)	−
Piperitone	+++++ (bad)	++++	+++	++	+
Pulegone	+++++	++++	±±	−	−
Carvone	+++	++	±	−	−
Linalool	++++	++	+	±	−
Menthol (10% alc. sol.)	+++++	+++	+	−	−

VI DEODORIZATION OF THE JAPANESE MINT OIL

In the Japanese mint (*M. arvensis*) oils we found some bad odorous constituents which depress the worth of commercial products. These odorous substances belonging to some amines[19] and carbonyl compounds[20] were found already by the writer. Now, therefore, the writer investigated the de-odorization of dementholized oils.

(a) Detection of Amine Compounds

In order to know the existence of amines in the samples (mint oil) the writer used the next three methods.

〔**Experimental**〕 1) Wagner method :– Reagent as dissolving 2g. of *iodine* and 6g. of *potassium iodide* in 100cc. of distilled water. Sample of mint oil is acidified with *sulfuric acid*, and added to this liguid the above reagent, then deposited precipitate of brown double salt.

2) Mayer reagent :– Dissolve 0.35g. of *mercuric chloride* and 4.98g. of *potassium iodide* in 100cc. of distilled water.

To the neutral or acidic solution added this reagent, then obtained white or pale yellowish precipitate or colored liquid.

3) Quinhydrone reaction :– Adding few gram of amines to 5% *ethanol* and then added 1cc. of *quinhydrone methanol* solution and stand 1~2 minutes, and then diluted with 5% *ethanol.* The coloration of amines are as the following :

Primary amine	purple color
Secondary amine	red ”
Tertiary amine	yellowish orange ”
Quaternary ammonium	greenish yellow ”

Taking the dementholized oil of "San–Bi" peppermint as a sample, the coloration by the above three methods were applied. The results are as the foilowing.

1) Few drops of the sample taken in the test tube, and introduced to wagner method. The coloration observed as : oil layer became brown color, but lower to pale yellow brown.

2) By Mayer method : oil layer became pale yellow-white color, but lower layer to pale yellow.

3) By *quinhydrone* reaction : oil layer became red color, but lower layer to pale yellow brown.

As the amine content is little, each coloring test showed the presence of amines in the sample oils.

(b) Removal of Amines

Amines are generally dissolve in dilute acids[21) 22)], the writer, in the first place, used dilute *sulfuric acid* and *hydrochloric acid.* The concentration of them are 6-*N*, 3 *N*, 2-*N*, and 1-*N*, respectively.

〔**Experimental**〕 Take 10cc. of the sample oil in 100cc. -stoppered bottle, add 5 volumes of above dilute acids and reacted by shaking machine for 15 minutes. The results are shown in Table 9.

Table 9. Deamination of Mint Oil

Normality of acid	Acids	
	HCl	H_2SO_4
1-N	pale yellow brown, upper pale yellow oil, resin, few	pale yellow, pale yellow oil, resin, few
2-N	pale yellow brown, upper pale yellow oil, resin, few	pale yellow, pale yellow oil, resin, brown
3-N	pale red brown, upper yellow oil, brown resin	pale yellow brown, brown resin, upper pale yellow oil
6-N	brown, upper red brown oil, brown resin	pale brown, dark brown resin, yellow oil, much resin

(c) Refining of the Oil

〔**Experimental**〕 The oil layer of the above experiments were separated and washed with five volumes of 5 per cent *sodium chloride* solution for 6〜8 times. At last wash with five volumes of water. Then the neutral oils were steam distilled. The results are shown in Table 10.

Table 10. Yield of Acid Treatment

Concentration of acid	Yield of HCl treat. (%)	Yield of H_2SO_4 treat. (%)
1-N	80.0	93.5
2-N	77.0	90.0
3-N	75.0	79.0
6-N	50.0	70.0

The steam distilled oils after treatment with dilute acids were colorless and clear, and deprived of an offensive odor to have fresh fragrance. But the oil treated with *hydro-*

chloric acid showed again pale yellow color after 3～4 days. The reason of this recoloration is yet in question. The oil yield is lowered on increasing the concentration of the acid.

The writer used, therefore, again very dilute *phosphoric acid* (as 0.1-*N*, 0.5-*N* and 1-*N*) and traced above experiments. The results are shown in Table 11.

Table 11. Treatment with Phosphoric Acid

Conc. of Acid	Appearance	Oil yield (%)
0.1-N	upper layer : pale yellow oil lower layer : white turbid	95.0
0.5-N	upper layer : pale yellow oil	87.0
1.0-N	upper layer : pale brown oil, few resin	85.0

Thus the dilute acid is more effective than concentrated acid for oil yield, deodorization and decoloration. More dilute solution of *hydrochloric acid* and *sulfuric acid* were used as before. The results were good in both reagents as in Table 12.

Table 12. Treatment with HCl and H_2SO_4

Conc. of acid	Oil yield (%)	
	HCl	H_2SO_4
0.1-N	93.0	80.0
0.5-N	85.0	85.0
1.0-N	80.0	93.5

The sample of San-Bi oil was colored yellow-brown, which is depend upon *furfural*[23] in the oil. By steam distillation of the acid-treated oil we obtained fine clear colorless oil.

(d) Improvement of Peppermint Oil

〔Experimental〕 Dementholized oil of San-Bi was treated with 0.1-*N phosphoric acid.* The results are shown in the Table 13.

Furfural reagent :- 2cc. of *aniline* is dissolved with 20cc. of 10% *acetic acid.* This reagent is added to the sample (0.3～0.4cc.), and the pink coloration is observed.

In this experiment the writer used most effective Schiff's reagent as :- Dissolve 0.25g. of pure fuchsin crystal to 250cc. of distilled water and filtered. Then, *sulfur dioxide* gas passed through this filtrate to saturation. Stand over night, then the colorless solution is usable[25] (Schiff and Caro's method).

The deamined oil, obtained by treatment with acid, has no more amine's reaction (see Table 14). Thus, the writer recognized surely the removal of the offensive odor of amines in the Japanese peppermint oils by the simple method using mineral acids.

Table 13. Properties of Peppermint Oil after Treatment with Phosphoric Acid*

Constants	Before	After
d_4^{25}	0.9025	0.8985
n_D^{25}	1.4670	1.4610
η^{25}	8.16	7.92
α_D	−31.31°	−30.92°
Combined menthol (%)	5.56	5.01
Free menthol (%)	68.37	66.23
Piperitone (%)	2.0	few
Furfural	+	−
Schiff's test	+	+

* The measurements of the oil were carried by Nagasawa's method[24].

Table 14. Detection of Amines in the Oil after Acid-treatment

Method	HCl		H_2SO_4		H_3PO_4	
	0.1N	6N	0.1N	6N	0.1N	6N
Wagner	−	−	−	−	−	−
Mayer	−	−	−	−	−	−
Quinhydrone	−	−	−	−	−	−

VII CONCLUSION

The elimination of the offensive odor of Japanese peppermint oil was succeeded by treatment with dilute mineral acids.

1) Using dilute mineral acids the writer removed the amines in peppermint oils.
2) Useful acids are *phosphoric acid, sulfuric acid* and *hydrochloric acid.*
3) Among these acids, 0.1-*N phosphoric acid* is most available.
4) By the acid treatment, the writer recognized that *furfural* was removed simultaneously.

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APPENDIX : PHOTOGRAPHS

Photo. 1. San-Bi (*M. arvensis*)
(Aug. 13, 1956 at Matsue)

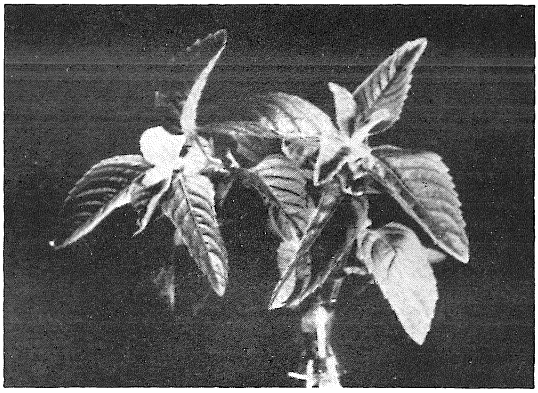

Photo. 2. Brazil-Mint (*M. arvensis*)
(June 1, 1957 at Matsue)

Photo. 3. Dog-Mint (*M. arvensis*)
(Aug. 5, 1957 at Matsue)

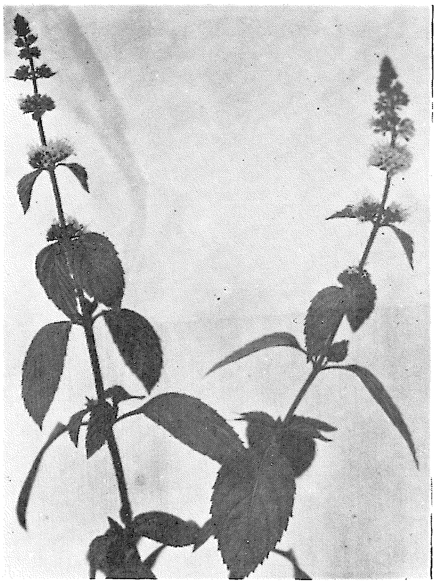

Photo. 4. Imaichi-Mint
(Hybrid of *M. arvensis*)
(Aug. 15, 1956 at Imaichi)

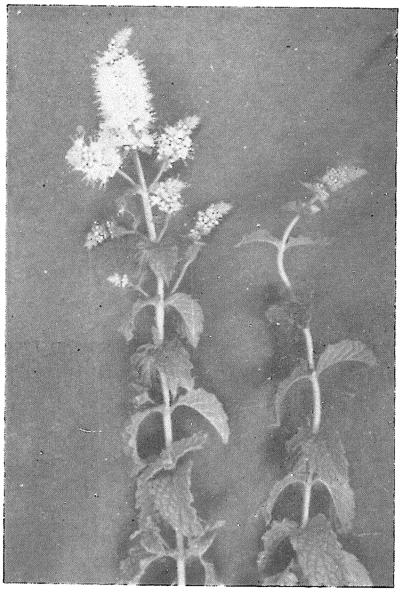

Photo. 5. Chirimen-Mint of Red-Stem
(*M. viridis*)
(Aug. 10, 1957 at Matsue)

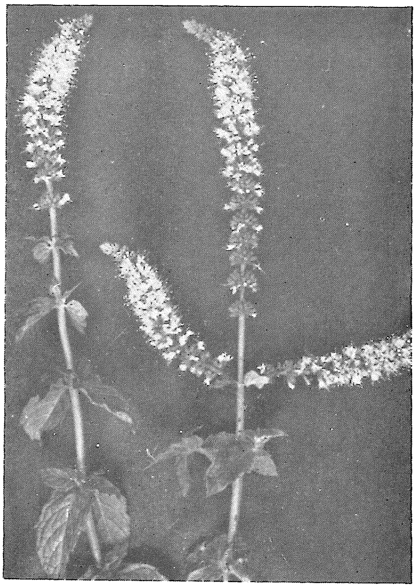

Photo. 6. Chirimen-Mint of White-Hair
(*M. viridis*)
(Aug. 15, 1957 at Matsue)

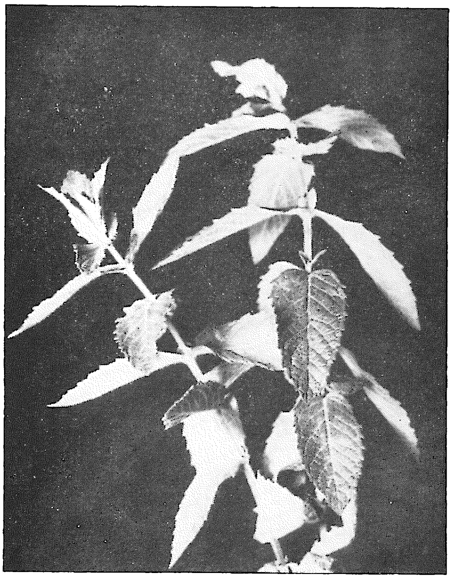

Photo. 7. Soviet-Mint (*M.viridis*)
(June 20, 1957 at Matsue)

Photo. 8. Pennyroyal (*M. pulegium*)
(June 13, 1957 at Matsue)

Photo. 9. Cutting of Mint Grass
(*M. arvensis*)
(Aug. 12, 1956 at Kurashiki)

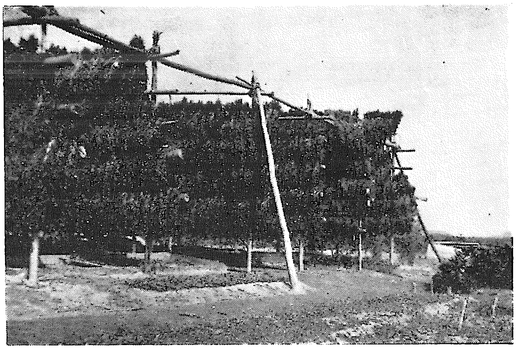

Photo. 10. View of Drying of
Mint Grass (*M. arvensis*)
(Aug. 15, 1956 at Kurashiki)

Photo. 11. View of Distillation of Peppermint Herbs (*M. arvensis*)
in San-Bi District
(Second crop, 1950, at Kurashiki)